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DoD Sensor Technology

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As Old As Warfare

Accurate Detection, Location of Enemy a Must

Since the beginnings of warfare the detection and location of enemy forces has been a formidable and challenging job. History is replete with battles that were lost because an unsuspecting commander let the enemy surprise him or slip from his grasp.

This was demonstrated during the Battle of the Bulge in December 1944, during World War II, when the Germans successfully increased their forces from nine to 26 divisions in six days, moving up under cover of darkness.

It was demonstrated during the Korean War when sizable Chinese Communist forces crossed the Yalu River against unsuspecting United Nations troops.

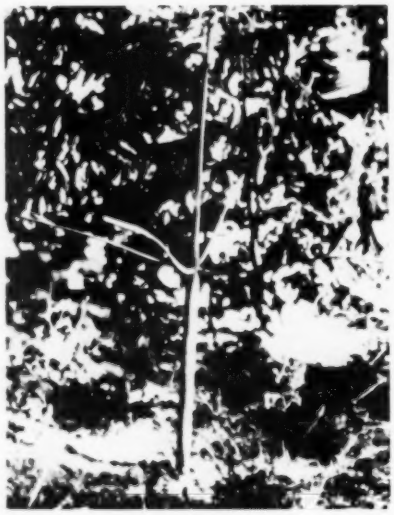
It was also demonstrated during the Tet offensive a few years ago in the Republic of Vietnam.

The newest technique for robbing the enemy of his traditional cloaks of bad weather, jungle and darkness is the sensor surveillance system. Basically, the job of sensors is to report enemy activity to a readout station, either directly or through an intermediary communications relay. At the readout facility the information is correlated with other intelligence inputs, and prompt action can be taken against enemy forces.

To illustrate the effectiveness of sensors, one type of acoustic sensor called the ACOUBUOY was dropped by drogue parachute in Vietnam. Generally placed in wide arrays to confirm the presence of suspected truck parks or storage areas, they transmitted with amazing clarity the many sounds associated with truck-park activity, such as hammering, chopping, bulldozers at work, etc. Even the voices of enemy soldiers could be clearly heard in casual conversations.

DoD Spurs Progress

The widespread use of sensors can trace its origins back to August 1966 when a scientific group known as the Jason Committee proposed to former Secretary of Defense Robert S. McNamara a remarkable concept to impede enemy troop and supply infiltration into South Vietnam. An air-supported barrier system and a conventional ground barrier



GROUND DETECTION—Hidden in the foliage in this photograph is an Air Delivered Seismic Detection Sensor (ADSID). The ADSID sensor electronically detects vibrations caused by enemy troops or vehicles.
(U.S. Air Force Photo)

system were to be established. This concept called for the first widespread use of electronic sensors to detect enemy personnel and vehicles. Once enemy forces were detected, U. S. tactical aircraft, mines and other weapons were to be called into action to prevent the enemy from successfully infiltrating into South Vietnam.

DoD Planning Group

A special organization, the Defense Communications Planning Group (DCPG) was established in September 1966, with responsibility to carry out the imaginative anti-infiltration system conceived by the Jason Committee.

Its first barrier system—called "The McNamara Wall" by the press—combined sensors to detect enemy infiltration through the DMZ, physical obstacles to impede and canalize enemy movements, and tactical troop units operating from strongpoints, or fortified bases.

While the original concept was never fully implemented, many types of sensor devices were successfully placed in operation in Vietnam on a high priority basis.

By the end of 1967, an initial anti-infiltration capability had been prepared and delivered to Southeast Asia within 15 months after the Secretary of Defense had given the go-ahead.

Since then the Department of Defense has sped forward with the research, development, testing and implementation of a number of highly-complex new electronic sensor devices and systems which promise to significantly alter the techniques of modern combat.

Original Programs

Originally there were three programs in the sensor area.

A Defense Special Projects Group (DSPG) program was initiated to develop general sensor and related equipment technology for the Services, a tactical ground sensor systems program to provide the Air Force Tactical Air Command with a worldwide all-weather sensor capability integrated into the tactical air control system, and an installations security program designed to improve the physical security measures of the U.S. Air Force and other Government agencies.

With the disestablishment of DSPG and the combining of the engineering development programs of tactical sensors and physical security, DSPG's tasks were distributed among the Services.

Basic Thrust

The Army, Navy, Air Force and Marine Corps are undertaking a variety of sensor technology programs which, when completed, will offer increased effectiveness for the individual combat soldier, sailor, airman or marine while according him greater physical safety. As Dr. John S. Foster, former Director of Defense Research and Engineering, said, "Remote sensors for interdiction and perimeter defense . . . can give detailed information about the position and strength of the enemy without risking our people."

Basic Concepts of Sensor Systems

The basic concepts of sensor systems are deceptively simple. The necessary elements are detection, transmission and receipt of the alarm signal, and actual activation of an alarm. But the subtleties, intricacies and ramifications of this simple process presents very significant technological challenges.

Undoubtedly the greatest challenge is the problem of detection—how to detect intrusion in a noisy environment. In exploring the possible technical approaches to intrusion detection, virtually every known form of sensing—including seismic, acoustic, magnetic, infrared, pressure and strain-sensing techniques have been examined.

Each of these techniques has the same basic problem. The intrusion results in the generation of a relatively weak signal in a world of high ambient noise.

The problem becomes one not of sensitivity but of differentiation—the differentiation between a potential intruder and the many and varied sources of extraneous sensor stimulation. The unintentional triggering of the device results in "false alarms," and the false alarm rate, usually expressed in alarms per hour, is an important parameter in sensing devices. If the false alarm rate is tolerably low, it represents only a significant nuisance; if it becomes too great, it renders the intrusion system essentially useless.

The problem of reliable and consistent detection with sensors has led to the application of more sophisticated techniques of signal processing. With this approach, a variety of sensors may be examined for their timing and logical sequence. The goal here is to recognize a distinctive signature in the sensing of an intruder as contrasted with the random patterns of noise.

Yet another detection challenge is presented by the variation in the behavior of sensing devices subjected to different environments.

A sensor system does not, of course, end at the point of detection. There must be a successful transmission of the indicated detection and receipt of that signal at the point of alarm.

Even the alarm deserves development consideration, since it involves a human

DETECTION—This schematic explains how the Directional Infrared Intrusion Detector (DIRID) sensor operates. The optical head is placed on a tripod or tree stake, then aimed to view the target area. Sensors monitoring the background heat radiation report background heat change of as little as one degree Farenheit, caused by an intruder.

Sensors Detect Enemy Movement

"Sensors denied the enemy his traditional cloaks of bad weather, jungle and darkness and detected his movements as he attempted to mount attacks. Khe Sanh operations showed a great potential for the use of sensors in support of ground tactical operations throughout South Vietnam. It is my considered conclusion that our combat surveillance systems have contributed materially to U.S. and Allied efforts in Southeast Asia; specifically, these systems have given us a combat surveillance and target acquisition capability which works by day, at night, and in many environmental situations; have improved the effectiveness of our air interdiction of the enemy's truck-borne troops and supplies; have given our ground troops early warning of attack and have freed small units from many security missions, thereby saving American and Allied lives and have enabled us to inflict an increased toll of casualties—and material damage—on the enemy."—**Major General John R. Deane Jr., U.S. Army, former head of Defense Communications Planning Group and a two-year combat leader in South Vietnam.**

engineering interface to the guard force or other designated observer. In its simplest form the alarm gives only an indication of intrusion—a bell sounds or a flashing light is activated. In more sophisticated intrusion systems, there is a variety of alternatives in displayed information and in possible reactions.

Typical energy fields monitored by counter-intrusion sensors are: magnetic, seismic, infrared (IR) radiation, pressure, strain, electromagnetic, and acoustic.

MAGNETIC SENSORS

Magnetic sensors detect changes in the local geomagnetic field caused by the movement of ferromagnetic objects within the sensor's detection range. The permanent or residual magnetism of an object carried or worn by an intruder distorts the local geomagnetic field. This distortion is detected by the sensor and when the sensor's detection criteria are satisfied, an intrusion alarm is generated.

SEISMIC SENSORS

Seismic sensors detect pressure waves caused by impacts on the earth's surface or by shifting inside the earth. Seismic sensors use a buried geophone to detect the earth-transmitted seismic wave. The geophone is typically emplaced vertically and as such, detects seismic waves traveling in the earth's surface plane and within a detection radius around the geophone.

INFRARED (IR) SENSORS

IR sensors detect an intrusion either by the interruption of an IR beam (active IR sensor) or by detecting the difference between an intruder's IR radiation and the background IR radiation (passive IR sensor). The active IR sensor generates a narrow IR beam which impinges on an IR receiver. When an intruder crosses the IR beam, the decrease in IR radiation is sensed by the IR receiver and an alarm is generated.

PRESSURE SENSORS

Pressure sensors detect the force of impact of an intruder on the earth's surface. This force is transmitted as a pressure gradient through the soil to the pressure sensor. When the magnitude of the pressure gradient at the sensor exceeds a threshold level, an alarm is generated. The pressure sensor is sensitive only to pressure in its immediate area. It cannot differentiate between the pressure caused by an intruder and a nuisance alarm source such as a passing animal.

STRAIN SENSORS

Strain sensors detect the soil stress caused by an intruder's weight. When the detected stress level exceeds a threshold level, an alarm is generated. Generally, strain sensors only detect stress relatively close to the sensor. This limited range and an adjustable minimum stress-level requirement can provide good false alarm rejection, especially in areas of high background seismic noise.

ELECTROMAGNETIC SENSORS

Active electromagnetic sensors generate a radio frequency (RF) field which is disturbed by an intruder. This disturbance changes the transmitting antenna impedance and causes the transmitted frequency to shift upward and downward as the intruder moves. These frequency shifts are used to determine the presence of an intruder.

ACOUSTIC SENSORS

Passive acoustic sensors listen for noises generated by personnel or vehicle intrusions. The noise signal is either processed and compared against detection criteria to determine if an intrusion occurred or a burst of sound is transmitted to a monitoring receiver for operator analysis.

Combining the technical challenges of remote sensors with the requirement for low cost, small-light sensors capable of being implanted by a variety of methods results in a complex engineering problem with many trade-offs, an almost infinite range of possible solutions, and a requirement for sophisticated techniques stretching the state-of-the-art.

OPERATION—An Army sergeant demonstrates the operation of a DIRID sensor (circled right) at the Mobility Equipment Research and Development Center, Fort Belvoir, Virginia.
(U.S. Army Photo)

As Sentries

J-SIID Sensors Detect Room Penetration

Since 1966, equipment used in several Army sensor systems has undergone several generations of operational and technological improvements to meet new requirements and to reduce costs.

The Army is utilizing the technological base established by Defense Special Projects Group (DSPG) and is now expanding upon it to meet new specific requirements. DSPG was tasked in December 1970 with the job of coordinating the Research and Development efforts in physical security, particularly in arms rooms, to prevent thefts.

Joint-Service Interior Intrusion Detection System (J-SIID) employs sensors to detect penetration of rooms, movement of intruders and touch or removal of protected items. It improves the security of any area by providing around-the-clock surveillance without the necessity of a 24-hour guard post or security forces in the immediate area. An intrusion alarm can be relayed by phone line to a nearby security post or used to alert the appropriate command personnel that a breach of security has occurred.

The J-SIIDs is composed of a family of sensors, a control unit, a monitor unit, a local audible alarm, a telephone dialer, and a Type I Data Transmission system.

The sensor categories within this system are as follows:

Penetration sensors—those detecting penetration into the arms room. This includes entry through doors, windows, walls, floors, ceilings and any other openings in the room.

Motion sensors—those detecting movement of a person inside the arms room.

Point sensors—those detecting the physical removal of a weapon from its storage container.

Duress sensors—those activated by an armorer or a guard to call for assistance.

The sensors and the control unit are located in the arms rooms. The control unit receives the signals from the sensors. These signals are then routed to the monitor unit, or the telephone dialer, as appropriate. The local audible alarm is attached to the outside of the room or building and gives notice to personnel in the area that the control unit has received an alarm signal from the sensors.

The monitor unit is usually located at the local base police station and/or in the charge-of-quarters office. The telephone dialer can be used as an alternate to the monitor unit, and upon receipt of an alarm signal, dials preselected telephone numbers such as local police, unit commander or some other person, to deliver a prerecorded alarm message.

The line supervision capability of the system causes an alarm to be sounded whenever wires connecting the components are cut or when an attempt is made to bypass the signal to the monitor unit. In addition, tamper sensors cause an alarm to be sounded whenever an attempt is made to disable one of the system components.

SECURITY—An Army sergeant monitors a series of Patrol Seismic Intrusion Detector (PSID) sensors. The PSID was developed to protect men, equipment, and installations from hit-and-hide enemy tactics. Small patrols deploy this sensor to safeguard against ambush or counter ambush operations.
(U.S. Army Photo)

Air Force AC-130 aircraft equipped with special sensors for locating and destroying enemy trucks.
(U.S. Air Force Photo)

Air Force Operation

Igloo White: A Cool Airborne Sensoring System

Igloo White—perhaps the most sophisticated electronic surveillance system ever employed in combat—was utilized by the U.S. Air Force to identify, track and destroy enemy forces infiltrating into South Vietnam during the Southeast Asia conflict.

Igloo White's basic elements were the sensors themselves, delivery aircraft, relay aircraft and a ground assessment facility.

All sensors in the system were delivered by air, most by Air Force aircraft. At first, delivery was accomplished visually. This, however, required good weather and easily identifiable terrain features, conditions not frequently found in Southeast Asia.

Lack of a high-speed delivery capability and the vulnerability of slower moving aircraft to antiaircraft fire forced high-altitude delivery of sensors, which resulted in large implant errors. After those early days, a high speed non-visual delivery by specially equipped F-4s was developed. Using this delivery technique sensors were normally delivered in strings along roads. Some strings consisted of the same type of device while others were mixed strings of seismic and acoustic sensors to provide an acoustic confirmation.

Against Truck Parks

In implanting sensors near truck parks, a typical array would use strings in parallel, consisting primarily of acoustic sensors to listen for truck park noises. These arrays were established by multiple passes of one aircraft or by one pass of several aircraft with lateral separation.

USAF Ground Support

Nerve center of Igloo White was the ground assessment facility, known as the Infiltration Surveillance Center (ISC). In the Igloo White operation, the size and complexity of the sensor field made computer assistance essential to correlate large numbers of activations over wide areas of operation.

Sensor data from the relay aircraft was electronically entered into the ground computer. The computer then produced a printout depicting activations of different sensors by their individual identifiers. These printouts were analyzed. From the activation patterns certain intelligence information could be derived. After a target was developed, it was passed on to the intelligence section for correlation with other source information. Then it was sent to the operations section for transmission to the airborne battlefield command and control center, which in turn directed strike aircraft in the combat area.

Besides locating targets for immediate reaction, the ground assessment facility, through analysis of enemy logistic flow

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patterns, also generated lucrative targets which were not time-sensitive. Those targets included truck parks and storage areas.

Sensors proved valuable as a detection source when coupled with an interdiction system having the capability to attack and destroy detected targets. In Southeast Asia this included the requirement for all-weather strikes while the targets were moving.

Ground sensors accomplished this for the Air Force in the following manner: when a target signature from a particular sensor activated, a sketch of the roadnet which that string of sensors monitored was called up on a cathode ray tube.

Computer Aid

The computer automatically displayed and updated the movement on the cathode ray tube of the target along that road segment. One or more F-4s were then instructed to enter the coordinates of a predetermined strike zone into the aircraft's computer. This gave the aircraft the course to that point, and automatically released the ordnance at the proper time to hit the target.

During the Vietnam War, sensors fulfilled the purpose for which they were intended. They found the truck convoys in real time regardless of weather and foliage conditions. Sensor intelligence was also used to establish most of the preplanned targets in Laos. They were the major sources of information on how many trucks entered and left the Ho Chi Minh Trail and permitted the Air Force to estimate the enemy's truck traffic level for any period.

Sensor Technology Used In Vietnam

The initial Defense Department capability was divided into two major systems: Duel Blade, which was the conventional system along the DMZ, and Igloo White, an air supported system in Laos, consisting of antipersonnel and antivehicular subsystems. Anti-infiltration efforts in the mountainous area adjoining Igloo White and Duel Blade were to utilize assets of either system, depending on the tactical situation and the requirement.

When these systems became operational their value was convincingly demonstrated. During the battle at Khe Sanh, the resources intended for the antipersonnel portion of the air supported system were diverted to meet the emergency. Sensors played a major role in the successful defense of Khe Sanh by the Marines against a numerically superior enemy combat force.

Later, on April 5, 1968, the Defense Communications Planning Group was directed to procure sufficient sensor programs. This project, nicknamed Duffel Bag, provided sensors for U.S. ground forces within South Vietnam rather than confining their use to the anti-infiltration role.

Lessons Learned

The success achieved with the present surveillance systems has led to the exploration of sensor uses at many levels of warfare. The Army, Navy, and Air Force have set up organizations responsible for exploiting the existing technology and for developing new technology, equipment and operational concepts tailored to fulfill combat surveillance and target acquisition missions in any type of warfare.

The success in Vietnam and the potential for the future offered by new technologies led the Secretary of the Army to approve in mid-1968 the appointment of an Army systems manager for STANO-Surveillance, Target, Acquisition, and Night Observation—the Army's "find the enemy" program which includes, as part of its total effort, the unattended ground sensor technology.

The STANO objective is to develop sufficient information so Army commanders can make sound, timely decisions and allow them to commit their forces in the most effective manner. Hardware systems pursued by STANO place great reliance on sensor systems.

After Vietnam

Project MASSTER is the Army field test and experimentation activity developing concepts for the future use of STANO devices. MASSTER was organized to provide the Army with an expanded and accelerated capability to evaluate from the soldier's point of view the merits and weaknesses of proposed hardware. Project MASSTER was activated at Fort Hood, Texas, on October 1, 1969. The term MASSTER stands for Mobile Army Sensor Systems Test, Evaluation and Review.

The Army desires in the next few years to take advantage of the advances in modern communications, automation, and advanced management procedures in order to digest and handle efficiently the information that moves within the combat zone. This approach is called the Integrated Battlefield Control System (IBCS).

IBCS will permit translation of the information supplied by the surveillance systems into meaningful intelligence about the enemy's activities and intentions. It will not automate the battlefield or make automatons out of soldiers. The decisions will still rest with the professional soldier. Most of the tasks will be performed by soldiers, aided by machines where possible. Commanders at every echelon will assess the information and react to it.

Other Services

The Navy is in the formative stages of exploring possibilities for the future use of sensor devices.

The Marine Corps does not plan to develop a unique sensor system. However, it will provide a training package of sensors for each of the three Marine divisions.

The current Air Force family of sensors was designed specifically for Southeast Asia. The system has demonstrated significant potential for enhancing future tactical operations worldwide, and the Tactical Air Command has stated a requirement for integration of Igloo White technology into its worldwide operational capability.

The Air Force is currently in a modest 5-year development program costing about $4 million per year.

This Igloo White deployable relay terminal backed up the Infiltration Surveillance Center in Southeast Asia. (U.S. Air Force Photo)

Collecting Data

Army Develops New Sophisticated Sensors

While the war was going on in Vietnam, different types of sensors were put into use as they were developed, without a comprehensive testing program to find out exactly what they could do and where the commanders could use them to the greatest advantage. This is now the job of the U.S. Army Waterways Experiment Station at Vicksburg, Mississippi.

Field teams from the station are collecting data from all over the world —from the tropics to the arctic, and from beach to desert and continental areas—to develop techniques for predicting the response of seismic sensors to men walking or vehicles moving under various environmental conditions.

These sensors are strongly influenced by the operational environment. For example, the silty deposits mixed with sand in the wide coastal plain areas in the south of Vietnam, similar to the deposits near the Hue-Phu Bai area in the north, exhibited excellent seismic characteristics. Soils that contain mixtures of silt, sand and/or clay, such as those in mountain valleys and the Mekong Terrace around Cu Chi, exhibit nominal seismic characteristics. Laterite deposits like those in the immediate area north of Saigon and the highly weathered and decomposed rock around Camp Eagle west of Hue exhibit some of the poorest seismic conditions found in the Republic of Vietnam.

Army Uses

Use of sensors in different locations where the seismic response has varied with both place and time has pinpointed a major problem area. Environmental features such as vegetation cover, weather, soil type and condition, and topography exert a controlling influence over the operational and technical performance of sensors.

Another serious limitation of present seismic sensors is their inability to deter-

Sensors Reduce Casualties

"Without any qualifications at all, I would say that unattended ground sensors and other surveillance devices contributed to the reduction of casualties . . . without doubt lives were saved because we had sensors both offensively and defensively. . ."—**Lt. General John M. Wright, U.S. Army, former commander of the 101st Airborne Division in the Republic of Vietnam.**

mine the source activating the sensor. Consider the greater value to a commander of a sensor flashing specific information on number and type of vehicles, and their speed and direction of travel. Research into sensor design is being undertaken in an attempt to approach these goals.

In order to produce the hoped-for products—a complete seismic sensor system and a map evaluating geographic areas of the world in terms of sensor performance—it was necessary to understand the interaction of the sensors and the environment.

Field Teams Formed

Before the teams of specialists formed at the Waterways Experiment Station could go out to collect environmental and seismic data, instrumentation that would be both compact and simple had to be designed, ordered and assembled.

The environmental data collection was designed to obtain information on surface and subsurface conditions, vegetation characteristics, topography and meteorological conditions. A seismic recording instrumentation package was acquired for conducting a refraction seismic survey. This would record amplitude and frequency measurements through the substrata, as a function of distance, for such targets as a man walking, a wheeled or tracked vehicle moving, and a controlled source of energy such as a drop hammer.

Additionally, the instrumentation would determine the naturally occuring background noise induced by wind and rainfall over which a target signal must be detected. The seismic equipment and the environmental instrumentation fit easily into two station wagons.

Field teams are continuing to collect data from tropical, arctic, beach, desert, and continental areas to develop techniques for predicting the response of seismic sensors to men walking or vehicles moving under various environmental conditions.

Some of this data has already been reduced and analyzed. An interim empirical model has been developed for predicting peak vehicle-velocity and displacement for a man walking as well as the calibrated source. A theoretical model has been devised which is capable of describing the detector response to a signal coming from a given signal generator in a given environment.

The theoretical and empirical studies are quite complicated because of the large number of environmental variables included. Because the operational products will have to be relatively easy to prepare and use, considerable effort on sensitivity analysis is planned in order to obtain the best possible model with the least number of input variables. The simplified model will then provide the framework for preparing guidance for operational use.

Army Agencies Involved

Agencies sponsoring work being performed by the Waterways Experiment Station include the Office, Chief of Research and Development; Tank Automotive Command; Mobility Engineering Research and Evaluation Command; the Project Manager's Office; Remote Battle Area Surveillance System; Defense Special Project Manager's Office; Remote Battle Area Surveillance System; and the Defense Special Projects Group.

Field teams have already obtained information at sites in Arizona, Florida, Mississippi, Maine, Virginia, Michigan, Puerto Rico, the Panama Canal Zone, West Germany and England. Some of the sites will be visited again to compare data obtained during both the dry and wet seasons. Additional testing is scheduled at Fort Greely, Alaska; Fort Bragg, North Carolina; Fort Huachuca, Arizona; several areas in West Germany, and the Vicksburg, Mississippi area.

SENSORS—Army Sergeant First Class Everett Brown shows how a sensor can be attached to a tree during testing operations at Fort Belvoir, Virginia. (U.S. Army Photo)

At Khe Sanh

Marines' First Real Test of Remote Sensors

The Marine Corps' first significant combat experience with remote sensors began during the initial phases of the battle for Khe Sanh in early 1968, when the Marine garrison, though tremendously outnumbered, held out against elements of the North Vietnamese Army.

Air-delivered seismic and acoustic sensors implanted by the Seventh Air Force provided the much needed intelligence information on enemy locations and movement near Khe Sanh. Intelligence and target acquisition information gained through the use of sensors was responded to with massive supporting arms.

According to DoD officials, the employment of sensors made significant contributions in providing the intelligence picture around Khe Sanh and assisted in target acquisition, resulting in the successful defense of the area and reduction in Marine casualties.

The successful deployment of the sensors in Khe Sanh resulted in the Commander, U. S. Military Assistance Command, Vietnam (COMUSMACV) developing a program for expanded employment of these devices throughout Vietnam. As the Marines increased their use of sensors, it was apparent that employment and management techniques were required to ensure maximum performance.

Accordingly, Fleet Marine Force, Pacific (FMFPac) requested that practical employment concepts be developed. Headquarters Marine Corps (HQMC) responded by directing that Commanding General, Marine Corps Development and Education Command (MCDEC), under Project STEAM (Sensor Technology as Applied to the Marine Corps), develop concepts of employment and sensor management techniques for use in Vietnam and for any subsequent contingency operations.

The Third Marine Amphibious Force directed an expanded sensor program in I Corps area, while Fleet Marine Force, Atlantic and Fleet Marine Force Pacific Conus forces in the spring of 1969 employed the same type of sensors and monitor equipment in Exercise Exotic Dancer II in Puerto Rico and Exercise Bell Call at Camp Pendleton, California.

MARINES—Seismic and acoustic sensors enabled the Marines at Khe Sanh to gather information on the enemy's location, thus permitting resupply and defense of the outpost. The sensors also provided the U.S. troops with target acquisition information, resulting in a reduction of Marine casualties.
(U.S. Marine Corps Photo)

These and many other successful applications of unattended ground sensors in Southeast Asia have proven that sensors can provide certain kinds of intelligence and target acquisition information more effectively than other methods. The tests illustrated that the initial concepts developed under Project STEAM, in particular, were valid.

However, it became apparent that specific personnel skills and highly trained units were required if sensors were to be employed to maximum effectiveness. In mid-1970 the Marine Corps initiated a program for providing the Fleet Marine Force with a sensor capability by organizing, training and equipping provisional Sensor Control and Management Platoons (SCAMPs) in each active division.

The initial concepts of employment, published in 1968, were critically reviewed and evaluated against the experience gained in exercises in 1969 and those conducted in 1970. The result: two development bulletins concerning the employment of sensors and surveillance concepts were issued by MCDEC in July 1971. Concurrently, HQMC established the provisional SCAMPs as permanent units in the permanent force structure.

Military Occupational Specialties were adopted to identify sensor-trained and experienced officers and enlisted Marines. Equipment allowances for the division SCAMPs were also published in the summer of 1971. Although sensors were developed for use in Southeast Asia, the Marine Corps has employed sensors on a continuing basis since 1968.

Geographically, test sensors have been employed by the Marines from the Philippines to Norway and from Maine to Panama. Climatically, they have been used in the heat of the desert and the cold of the New England winter. Operationally, they have been used by the Marines in amphibious, mechanized, desert and mountain warfare operations.

Marine Corps forces, as well as all military forces, have historically had requirements to detect, locate, identify and monitor enemy activity. Remote sensors, originally intended for target acquisition in the anti-infiltration environment, have made significant contributions toward satisfying this and the intelligence collection requirements within the FMF. The role of sensors now in the FMF is primarily intelligence collection and surveillance. While target acquisition is definitely within the capability of sensors, it is not considered their primary function.

Marine Sensor Types

The Marine Corps employment concepts include three types of operational employment of sensors. In the first type, sensor devices are monitored directly by the using unit. Information is immedi-

ately evaluated by a unit and appropriate action initiated by that unit. Monitoring devices normally used in this type of employment are lightweight, simple and single channel. Data and information acquired by sensor monitoring is treated as both intelligence and target data, and is disseminated through established communication channels as normal intelligence information.

A second type employment involves monitoring sensors over a broader area by a complex multi-channel facility, normally located at regimental or higher headquarters. Intelligence and target acquisition information derived from sensors here is disseminated laterally and to higher and lower echelons capable of taking appropriate action.

The last type of operational employment involves sensors employed for purposes of other than direct combat support of forces. It encompasses the strategic and tactical deployment of sensors into areas where immediate combat action is not contemplated but where surveillance is required.

In accomplishing the three types of employment, units of the division SCAMPs provide Sensor Employment Squads (SES) to infantry regiments and Sensor Employment Teams (SETs) to infantry battalions, while at the same time maintaining a sensor monitoring capability at the Marine divison level.

The SETs at battalion level are equipped with lightweight, man-portable monitoring equipment, while the division and regiment facilities are multi-channel, helicopter-transportable equipment capable of monitoring up to 240 sensors simultaneously.

Because of the unpredictable radio signal characteristics transmitted by the sensors, relays are normally required to extend their range. Within SCAMPs, assets are one and two-channel ground emplaced relays. Also available are multi-channel relays which are pod-mounted and capable of being carried on high-performance tactical aircraft.

Sensors are presently deployed into planned areas by Marine ground forces and by air. The present air-deployable capability includes helicopter delivery and delivery by 0V-10 aircraft.

A high-performance aircraft delivery capability is currently under consideration and should be available to the Fleet Marine Force in the near future.

The Marine Corps sensor program is closely monitored and guided by HQMC and MCDEC and supported by and through the Navy Special Remote Sensor Systems Project Office in the Navy Electronics Command. That office is responsible for the development efforts to improve the sensor system developed for Southeast Asia and make it more compatible with Marine Corps requirements.

Electronic Battlefield a Valuable Adjunct

"The actual battlefield of the future won't be much different from the past. The red mud of Khe Sanh in 1968 was very much like the mud of Flanders in 1918 to the young men living and fighting in it. The sensor and electronic battlefield as it existed at Khe Sanh was an extremely valuable adjunct to the defense."—**Colonel David Lownds, Commanding Officer of Marines at Khe Sanh**

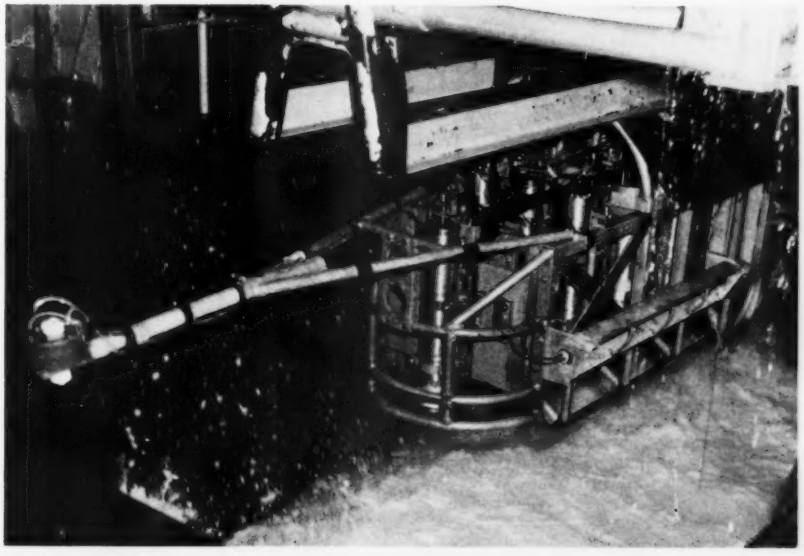
Monitoring Shipping Channel

Naval Use of Sensors in SEA Began in 1968

The U. S. commander in South Vietnam directed that sensors be provided for Navy operations during August 1968. Tests were conducted to determine the immediate capabilities of on-the-shelf sensor items as related to:

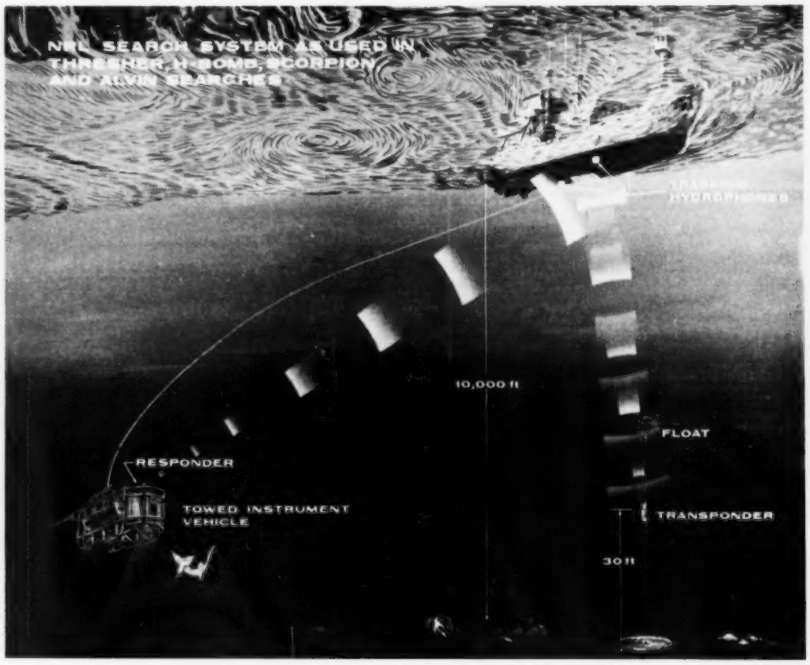
- Detection of canal traffic;
- Enemy base area targeting;
- Mobile riverine base defense; and
- River ambush detection.

The test results proved that existing



DEEP SEA PROBE—The Naval Research Laboratory has developed this Responder sensor for deep-sea probes. It is instrumented with side-looking sonars, strobe lights, telemetry and control equipment, and a magnetometer. The Responder is towed by a 22,000-foot long cable. (See related photo on page 12.) (U.S. Navy Photo)

TRACKING—The Naval Research Laboratory has designed a special underwater tracking system installed aboard the USNS Mizar (T-AGOR-11). As depicted here, the deep-sea research and inspection system has three hull-mounted hydrophones receiving acoustic signals emitted from underwater sound sources. (U.S. Navy Photo)



items had direct application for the Navy in all of these areas.

The first Navy monitoring site was established in August 1968 to monitor traffic in an area contiguous to a shipping channel leading to Saigon.

After the Navy recognized the value of sensors, the Commander-in-Chief, Pacific Fleet and the Commander-in-Chief, Atlantic Fleet, in 1969 tasked their amphibious forces with the responsibility for evaluating Navy employment of remote sensors.

Amphibious Forces, Atlantic and Amphibious Forces, Pacific organized small units dedicated to the utilization of remote sensors to provide task force commanders with real-time information on enemy activities.

The Navy has been employing sensors for surveillance in amphibious objective areas since 1969. Their purpose has been to detect the presence, activities and movement of aggressor forces and to identify targets to be attacked both before and during an assault.

Data provided by such sensors has significantly influenced amphibious task force commanders' selection of assault beaches and helicopter landing zones as well as the requirement for preparation fire into these areas.

In practice, remote sensors provided the bulk of the real-time or near-real-time intelligence information available to the commander of the amphibious task force during the pre-assault and assault phases.

The remote sensor system used by amphibious forces consists of three major components: sensors, relays, and monitor receivers. The sensors are designed to detect changes caused by enemy activity in the physical environment in which they are deployed.

Naval Sensor Types

Three primary types of sensors used by the Navy are seismic, magnetic and acoustic, which detect movement, metal, or noise. The relay of information transmitted by the sensors is accomplished by both airborne and ground devices. In recent exercises, airborne relays allowed shipboard personnel to monitor aggressor activity in an operating area while enroute to the area.

Two types of mobile sensor monitoring facilities have also been successfully used by Naval amphibious forces. One type consists of a small, portable, single-channel monitor-receiver about the same size as a small transmitter. The other is a multichannel facility housed in a helicopter-transportable shelter. One of these unique shelters was embarked on the landing craft Mount Whitney (LCC-20) and was used to monitor sensors in amphibious operating areas during recent fleet exercises.

Aside from the hand emplacement of the sensors by special warfare forces, the Navy at present has no capability to emplace remote sensors in enemy territory. However, work is now underway to develop tactics of emplacing sensors employing carrier-based high-performance aircraft.

Current efforts are being directed to developing broader applications for sensors used in support of amphibious and air forces. Sensor systems can also be used by surface forces to fill gaps in their surveillance capabilities of seacoast areas or to provide more timely information on targets within assigned areas.

Sensors Give Information

"Remote sensors for interdiction and perimeter defense . . . can give detailed information about the position and strength of the enemy without risking our people."—**Dr. John S. Foster, former Director of Defense Research & Engineering.**

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